Simulation of Fuel Cell/Turbine Hybrid Power Systems

2nd DOE/UN International Conference and Workshop on Hybrid Power Systems

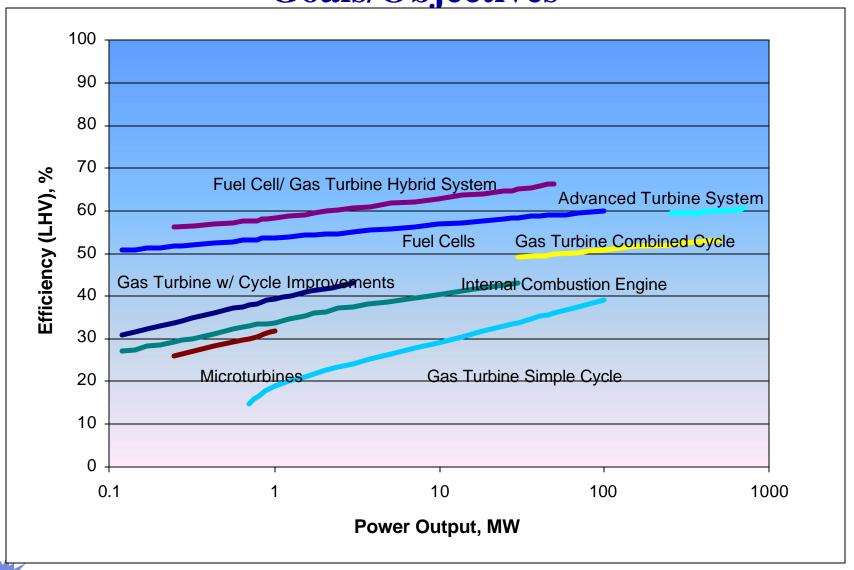
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Goals/Objectives





Technical Challenges

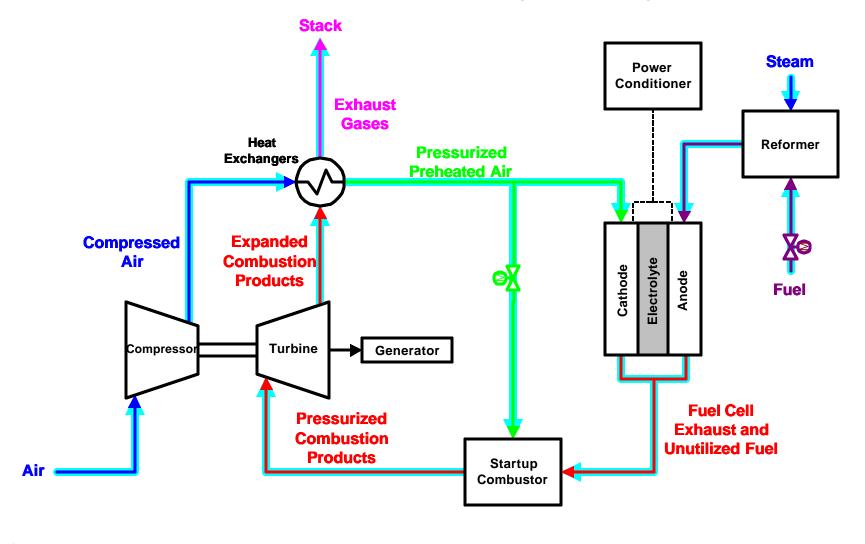
- Dynamic interdependencies of fuel cell gas turbine hybrids need to be identified.
- Methods for managing thermal and load transients need to be developed.
- Imposed stress on both the fuel cell and the turbine in the hybrid system needs to be minimized.
- Control strategies for load following need to be developed.



Approach

- Develop dynamic computer models to help identify and understand issues related to systems integration.
- Use Dynamic models to provide direction in developing experimental methodology.
- Design and build an experimental system capable of examining potentially abusive dynamic conditions in a fuel cell gas turbine hybrid.
- Perform experiments to identify problems and test solutions.

Fuel Cell Gas Turbine Hybrid System



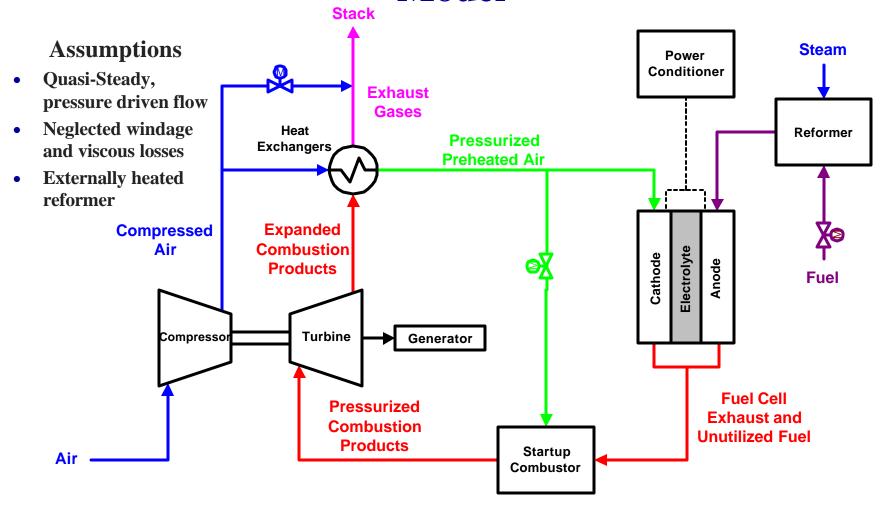


Testing Scenarios

- Startup
- Loss of load to the fuel cell during steady state operations
- Loss of load to the turbine during steady state operations
- Shut down
- Fuel cell turn down or load following
- Gas turbine turn down or load following
- Compressor stall and surge

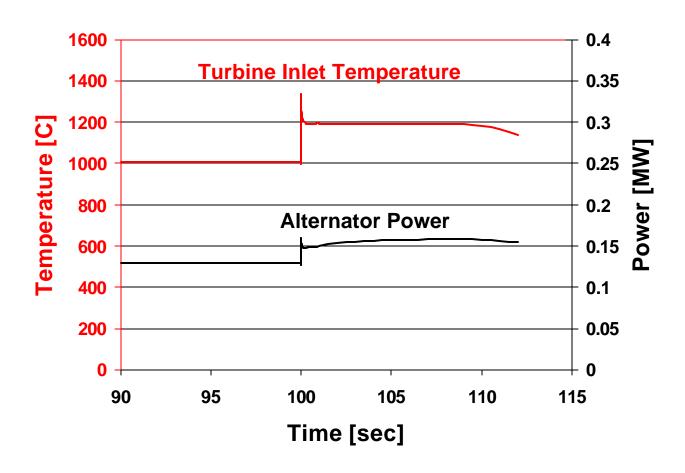


250kW Direct Fired SOFC/Turbine Hybrid Model



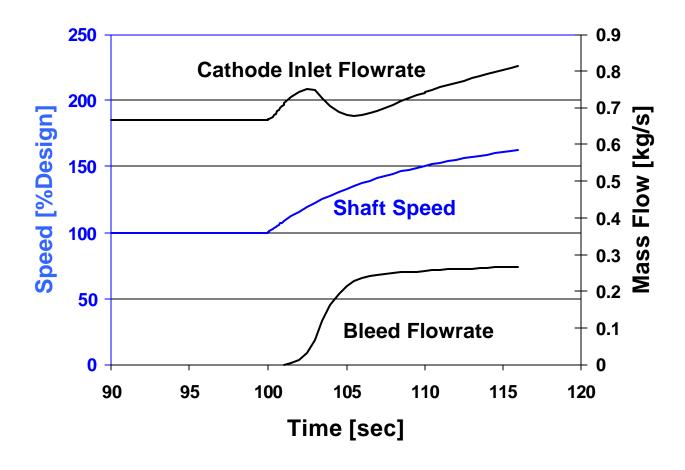


Loss of Load to the Fuel Cell with Fuel Shut Off



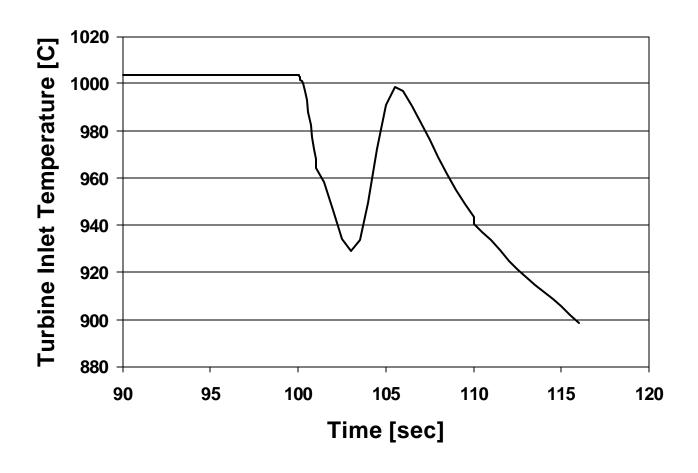


Loss of Load to the Turbine with Bleed Air Load Control



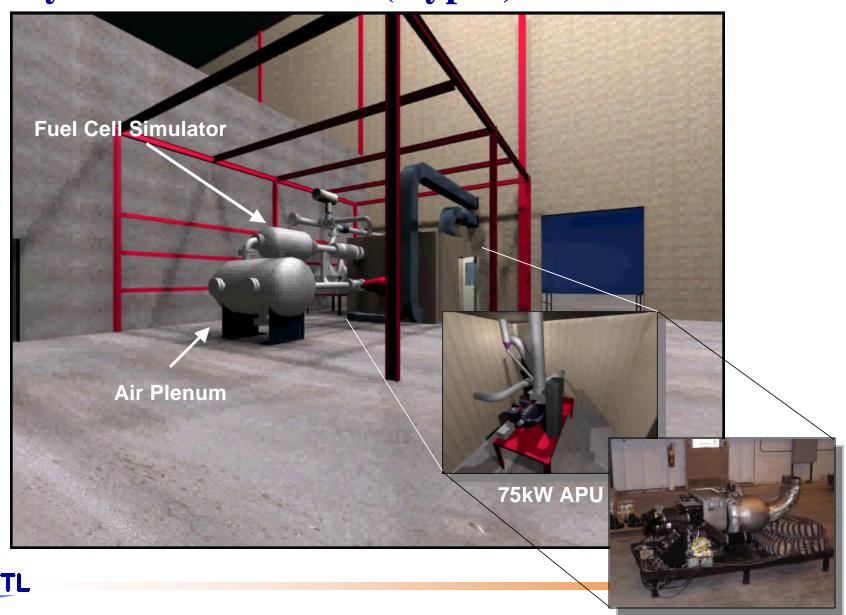


Loss of Load to the Turbine with Bleed Air Load Control

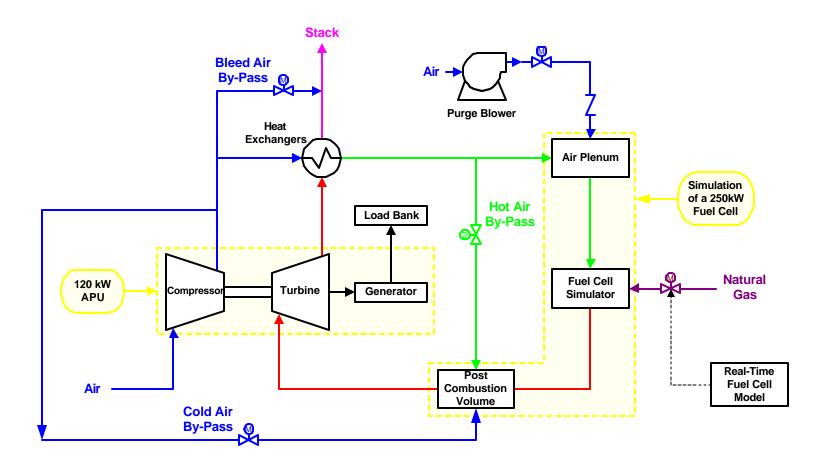




Hybrid Performance (Hyper) Test Facilities



Overview of Hybrid Simulation Facility

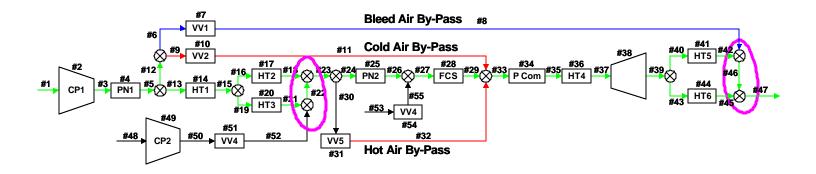




Experimental Hybrid System

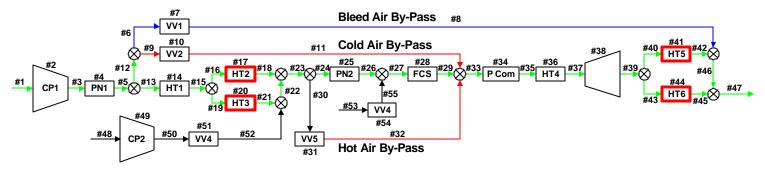


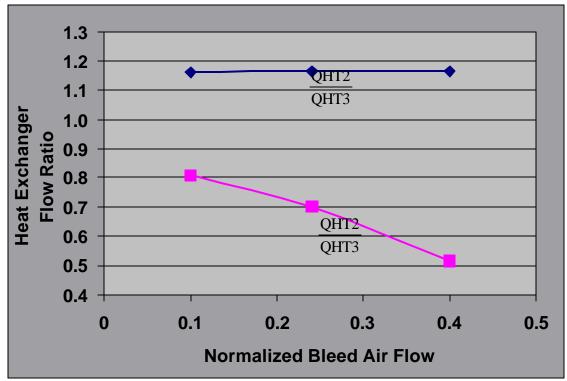
Flow Element Model of the Hybrid Simulation Facility





Effect of Piping Asymmetry on Heat Exchanger Flow During Bleed Air Operation







Research Plan- Phase I Speed Control and System Characterization

Effective Speed Control During Startup and Load Change Stack **Time Scales and Bleed Air Dynamics Characterized** By-Pass M **Turbine Efficiency Over Varied loads for Oversize Purge Blower Bleed Air Load** Heat **Possibilities Exchangers Absorbing Thermal** Air Plenum **Transients** Simulation **Electrical Load** of a 250kW **Hot Air** Fuel Cell Load Bank **By-Pass** Fuel Cell Natural 120 kW Compresso Turbine Generator Simulator APU Gas Forward Feed **Model Based** Speed Control **Turbine Speed** Post Combustion Volume **Cold Air** By-Pass 🚳

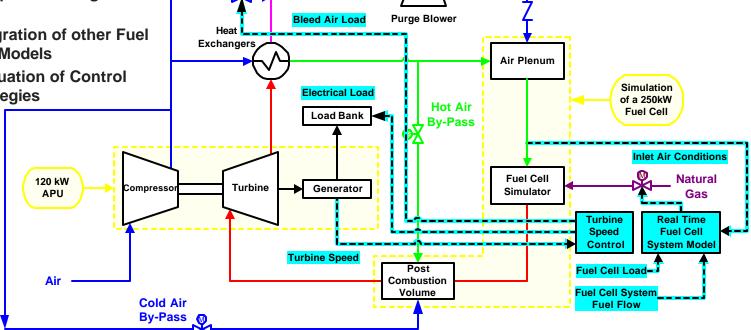


Research Plan- Phase II Fuel Cell Simulation

Stack

By-Pass

- **Integration of Real Time** Fuel Cell Model
- **Turbine Speed Held Constant Through** Variation of Load
- Loss of Load to the Fuel Cell and Other Transients Bleed Air
- **Compressor Surge and** Stall
- Integration of other Fuel **Cell Models**
- **Evaluation of Control Strategies**





Research Plan- Phase III Independent APU Speed Control and Load Enllowing

Following Secondary Combustion System for Independent APU Speed Control Stack Loss of Turbine Load **Bleed Air** By-Pass **Load Following Evaluation and Impact Purge Blower Bleed Air Load Stall and Surge Dynamic** Heat **Exchangers Studies** Air Plenum **Evaluation of Control** Simulation **Strategies Electrical Load** of a 250kW **Hot Air Fuel Cell** Load Bank **By-Pass Inlet Air Conditions** Fuel Cell **Natural** 120 kW Compresso **Turbine** Generator Simulator APU Gas Turbine Real Time **Fuel Cell** Speed System Model Control **Turbine Speed** Post Combustor **Fuel Cell Load Cold Air Fuel Cell System** By-Pass **Fuel Flow Natural** Gas



Research Plan- Phase IV Integration of a Commercial Fuel Cell

